Cross River Gorilla (Gorilla gorilla diehli) conservation in a changing landscape of the Lebialem-Mone forest, South West Region, Cameroon

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Abstract

A sub-population of the Cross River gorilla-CRG has been discovered in the Lebialem-Mone Forest landscape (LMFL). The gorillas are found in a non-permanent forest estate meaning that this area can be converted into any form of land use other than forestry. Fauna and Flora International-FFI and the Environment and Rural Development Foundation-ERuDeF are working towards designating a wildlife sanctuary for this CRG and other biodiversity but to proceed with the proposed plan, field information is mandatory. Primates are known to be vulnerable to forest cover destruction. This research therefore intends to assess the changes that have occurred in the site over time as well as identify the drivers of the change which serve as challenges for protecting the habitat. In order to attain these objectives, Landsat and SPOT satellite images for 1986 and 2011 respectively were analysed to assess the change. Interviews and observations were used to identify the drivers of change and current challenges of protecting biodiversity as a whole in the landscape. The major results proved that forest cover reduced from 80% in 1986 to 66% in 2011 while disturbed forest and farmland both witnessed an increased from 11% to 22% and 2% to 4% respectively. From interviews, 84% of the population were actually aware that changes had occurred and the main drivers of this current change were identified by 69%, 12%, and 10% of
those interviewed to be farming, house construction and timber exploitation accordingly. The study suggests that for the gorilla habitat to be conserved, alternative means of income to take the local population off the forest have to be sought. This could be beekeeping, snail and cane rat farming, intensive agriculture with the use of fertilizers and high yielding species so that cultivated portions can produce much quantities and part of the land left for wildlife (land sparing).

**Keywords:** remote sensing, satellite images, cross river gorilla, western Cameroon, Lebialem-mone forest landscape

1. **Introduction**

People are in the process of changing ecosystems more rapidly and extensively today than in any comparable period of time in human history. This has been largely to meet rapidly growing demands for food, fresh water, timber, fibre and fuel. The primary causes of this loss in biodiversity and even those harboured by protected areas (PAs) which include habitat change, overexploitation and introduction of invasive alien species, nutrient loading and climate change currently show no sign of abating (Secretariat of the Convention on Biological Diversity-SCBD, 2006). This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth (Millennium Ecosystem Assessment-MEA, 2005a). A high proportion of natural ecosystems have already been converted to human dominated uses, such as cropland (Trumper *et al.*, 2009). As a result of the demand, more land was converted to cropland in the last 30 years after 1950 than in the 150 years between 1700 and 1850 (Millennium Ecosystem Assessment-MEA, 2005b). Out of the 24 ecosystem services assessed by the MEA, 15 are in decline (SCBD, 2006). According to the International Union for Conservation of Nature-IUCN (2006), over 16 000 species have been identified as threatened with extinction and of the major vertebrates that have been comprehensively assessed; over 30 percent of amphibians, 23 percent of mammals and 12
percent of birds are threatened. Of the 5,488 recognised mammal species in the world, 1,141 are threatened with extinction representing over 20% of the species evaluated, according to the Red List Index 2008 (Vié et al., 2008). Entire forest ecosystems have disappeared from 25 countries and have declined by 90% in a further 29 (United Nations Environment Programme-UNEP, 2009). Biodiversity loss disrupts ecosystem functions, making ecosystems more vulnerable to shocks and disturbances, less resilient, and less able to supply humans with needed services. The damage to coastal communities from floods and storms, for example, can increase dramatically where protective wetland habitats have been lost or degraded. Tropical forests, many wetlands and other natural habitats are also shrinking in size (SCBD, 2006).

In order to reflect on the means of curbing the stress on biodiversity and the earth’s resources and to bringing nations together to reach global agreement on sustainable development, the international community organized the Earth Summit in 1992 as a follow up to the 1972 United Nations Conference on the Human Environment and the recommendation of the 1987 Brundtland Report. One of the major outcomes of this conference was the adoption of the CBD. The CBD has as objectives, the conservation of biological diversity, and the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources (SCBD, 2005). A landmark in international law, the Convention together with its Cartagena Protocol on Biosafety, is an integral part of international efforts to achieve sustainable development, poverty alleviation and the United Nations Millennium Development Goals (SCBD, 2004).

Cameroon signed and ratified the CBD in 1992 and 1994 respectively. Subsequently, a new forestry, fisheries
and wildlife regulation was enacted in 1994. According to the current law N° 94/01 enacted on 20 January 1994, on forestry, wildlife and fisheries regulations, the country’s forestry estate is divided into permanent and non-permanent forest estates (Table 1). Permanent forests comprise lands that are used solely for forestry or as a wildlife habitat and should cover at least 30% (the law does not state when this 30% target is supposed to be attained) of the national territory (Ministry of the Environment and Forestry-MINEF, 1994).

Table 1: State forests in Cameroon

<table>
<thead>
<tr>
<th>Wildlife Areas protected</th>
<th>Forest reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>National parks</td>
<td>Integral ecological reserves</td>
</tr>
<tr>
<td>Game reserves</td>
<td>Production forests</td>
</tr>
<tr>
<td>Hunting areas</td>
<td>Protection forests</td>
</tr>
<tr>
<td>Game ranches</td>
<td>Recreation forests</td>
</tr>
<tr>
<td>Wildlife sanctuaries</td>
<td>Teaching and research forests</td>
</tr>
<tr>
<td>Buffer zones</td>
<td>Plant life sanctuaries</td>
</tr>
</tbody>
</table>

Source: MINEF, 1994

Non-permanent forests comprise forestlands that may be used for other purposes than forestry (MINEF, 1994). It therefore means according to this law that no matter the biodiversity wealth of an area, the government pays no major attention in its protection if it does not fall within any of the categories of state forests shown in table 1. One of such areas which have been discovered to be biologically rich but found outside state protected forests is the Western Cameroon landscape constituted specifically of the forests and ecosystems of the LMFL. This area has been discovered to harbour a subpopulation of the Cross River gorilla (Gorilla gorilla diehli). Alongside the CRG, this landscape is equally renowned for harbouring chimpanzees, monkeys, buffaloes, antelopes, hippopotami, and elephants amongst others. Contrary to other areas in the landscape where this
rich biodiversity is being conferred some form of legal protection via PAs, that of the LMFL is found in a non-permanent forest estate (Figure 1).

The presence of the LMFL in a non-permanent forest estate area implies that the administration or the communities can use this area for other purposes than forestry. The situation on the ground reveals that, despite being almost sandwiched by a number of PAs making it a good corridor for wildlife migration between the PAs (Figure 2), this landscape has in the past been allocated for timber exploitation. A large scale oil palm plantation is going to start close to the area by Herakles Farms, and the sales of standing volumes have been advertised\(^1\) and while the local population carry out their daily subsistence activities for survival on the same landscape, FFI and ERuDeF are striving to conserve it by creating a wildlife sanctuary for the protection of the CRG. The IUCN Red list

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\(^1\) Sales of standing volumes, (Ventes de coupe) is a type of logging permit of 2,500 hectares (maximum) allocated for 1-3 years (Collomb and Bikié, 2000)
status\textsuperscript{2} changed from vulnerable in 1986 to endangered in 1996 and finally to critically endangered in 2007 (Walsh \textit{et al.}, 2008 and Bergl \textit{et al.}, 2008)\textsuperscript{3} and according to Nicholas \textit{et al.}, (2010), the Cross river gorilla found in unclassified forest areas in Cameroon are arguably the most vulnerable sections of the remaining population. The Cross river gorilla found in the Lebielem-Mone Forest Landscape falls amongst these categories since the area has not been designated for any form of legal protection.

In order for Fauna and Flora International and partners to proceed, knowledge about the changes that have occurred in the area over the past years, an up-to-date situation of the landscape as well as the current and emerging challenges of protecting the habitat is very necessary. This is because for an effective and sustainable natural resource management system to be put in place, information is needed regarding what changes have occurred, where they occur and the social and physical forces that drive those changes (Lambin \textit{et al.}, 2003). Equally, new and improved methods to analyse and evaluate the existing situation; facilitate projection of future trends and impacts are needed. Direct field survey and traditional techniques which are time and money consuming as well as very strenuous could not no longer meet up with the challenges of forest and land use change. Data gathered by remote sensing for the same area over time are instrumental to assess changes in landscapes and associated factors (Wiens \textit{et al.}, 2009). Since satellite images

\textsuperscript{2} The IUCN Red List of Threatened Species is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species. \url{http://www.iucnredlist.org/about/red-list-overview#introduction} accessed on 20/08/2013.

\textsuperscript{3} The CRG occurs only in the forested region straddling the international border between Cameroon and Nigeria (Sunderland-Groves \textit{et al.}, 2009) and only about 300 of them remain (Bergl, 2006).
can be consistent through time (Jones et al., 2009) and provide a synoptic view of spatial land cover, they have become important tools for conservation (Townsend et al., 2009). It is for this reason that the present study employed Landsat and Système Pour l’Observation de la Terre (SPOT) images of 1986 and 2011 respectively, coupled with fieldwork to attain the objectives of the study.

2. Methodology

2.1. Location of Lebialem-Mone Forest Landscape in Cameroon

Administratively, the Lebialem-Mone Forest Landscape is found in the South West Region of Cameroon but in geographic terms, in the west of the country (Figure. 3). The South West Region is one of the ten administrative regions of Cameroon. Along with the North West, it is one of the two Anglophone (English-speaking) regions of the country. This region had a population of 620,515 inhabitants in 1976 and is estimated to have 1,534,232 people in 2015 (BUCREP, 2010b). With a surface area of 24,910 sq km representing approximately 5.4% of the total surface area of Cameroon, this region presently has 6 divisions viz: Fako, kue-Manengouba, Lebialem, Manyu, Meme and Ndian. The LMFL spans through the Lebialem and Manyu divisions of this region.

2.2. Remote sensing and GIS methodology

2.2.1. Acquisition of images

As the study entailed an assessment of the change that has taken place in the Lebialem-Mone Forest Landscape over time, satellite images for two distinct periods were used. SPOT 5 and Landsat Thematic Mapper (TM) satellite
images were employed. The SPOT images were obtained for free from Fauna and Flora International while the Landsat images were downloaded (equally for free) from the Global Land Cover Facility of the University of Maryland ([http://glcf.umiacs.umd.edu/](http://glcf.umiacs.umd.edu/) accessed on 04/06/2012). The scenes “Ids” for the SPOT images were 4079338101213093754115 and 4080338110108093653118 acquired in December 2010 and January 2011 respectively at 20m resolution.

Figure 2: Location of the Lebialem-Mone Forest Landscape amongst protected areas and other forms of land uses in SW Cameroon

The paths and rows for the Landsat images were p187r56_5t861212 and p186r56_4t880202 obtained in December 1986 and February 1988 correspondingly at 30m resolution\(^4\). Images obtained during this period correspond

\(^4\) The gap between the two scenes of Landsat is not that wide as to bring any significant change in the results.
to the dry season in this part of the country and so permit a greater capture of surface features since the atmosphere over this region is free from cloud cover to a greater extent. This enables a clearer visibility of surface features during image interpretation and analysis.

Figure 3: Location of the Lebialem-Mone Forest Landscape in Cameroon
2.2.2. Image preparation

The SPOT images obtained from FFI were already stacked. A false colour or near infrared (NIR) composite using bands 432 was used. The same band composition was utilized for the Landsat images. In a 432 NIR composite image, vegetation is vividly depicted as varying shades of red. This makes the composite very useful in determining the extent of vegetation against other land use classes as seen from space. Since the study site spans two scenes of both the SPOT and Landsat images, a mosaic function was needed to blend each of them together (that is the two scenes of the SPOT and the two scenes of the Landsat images). This was performed in Erdas Imagine 9.1. The smooth alignment of linear features such as roads and rivers straddling both images were employed as testimony to the success of the mosaic operation. In order to make sure that images of the same area were being treated, an overlay function (where the SPOT image was overlaid on the Landsat or vice versa) was used to further verify that the images overlapped exactly across all two dates. This was done by visually swiping overlaid images confirming that linear features such as roads and rivers superimposed exactly on one another. This is essential to ensure that changes observed from year to year are a result of actual land-cover change and not compounded by errors in co-registration (Nagendra et al., 2006). Since the satellite images cover a very large area, the digitised boundary of the study area acquired from FFI in “shapefile” was overlaid on the satellite images and a subsequent clip operation employed to acquire the area of interest (AOI).
2.2.3. Image classification

Land cover classification was conducted using a supervised classification approach in MultiSpecWin32. Supervised classification employs user-defined spectral signatures (from selected groups of pixels) representing known land cover types to “train” the classification programme. The programme uses these spectral signatures to identify pixels in the image with similar reflective characteristics and assign them to the appropriate land cover class. In order to relate patterns of land cover class on the ground to the satellite Images, 100 ground-truthed land cover points were collected (Figure 4) with the use of Garmin GPSmap 62s receiver. These points were recorded opportunistically during each day of field work. For each land cover point, habitat type and geographic coordinates were recorded. A field collection sheet was designed for this purpose. The land cover classes for the ground-truthed GPS points were combined to match the set of classes and used to assess the accuracy of the classification for the SPOT image which was 96 %.

A general classification scheme that included 5 land cover categories was defined. These were; water-body, road/settlement, farmland, undisturbed forest and disturbed forest. The resulting output was imported into Erdas Imagine and statistics for each class obtained automatically from the attribute table. The raster format was then converted to polygon features in ArcGIS 9.3 and two land cover maps (1986 and 2011) for the LMFL were produced and exported in jpeg format for easy processing and printing as an office document.

In order to obtain the change in land cover, the following formulae (Otukei, 2006) were used: Percentage area of class= AC/ATx100; ΔC= Area (%) recent year – Area
(%) old year; where AC= area of the cover class, AT=total Area, ΔC=cover change.

2.3. Gathering community perceptions of change in the land cover across the landscape

2.3.1. Administering of questionnaires

A total of 96 questionnaires were administered in 12 villages of the LMFL repartitioned between the Lebialem and Manyu Divisions of the South West Region of Cameroon (Table 2). In each of the villages visited, the first point of contact was the Chief’s\(^5\) palace where the *raison d’être* of the visit was explained. In the absence of the chief (like in Besali, Folepi and Takwai) the second in command

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\(^5\) In our area of study, the chief is the representative of the administration and the custodian of the law
was contacted. Their consent was sought before one could carry out activities in their area of jurisdiction. The study took place in the weeding period of the planting season (an activity that is predominantly carried out by women) meaning that they were usually absent from their homes during the day and so men constituted the target group (6 women were interviewed).

In each village, the first three questionnaires were administered using the “snowball” sampling technique. Concretely, after interviewing the Chief or his representative, he was asked if he knew somebody who was versed with the issue of forest change and management in the village. From here, the researcher was either accompanied by somebody from the palace to the suggested person’s house or he was called to the palace and then the questionnaire administered in-situ. The third person was gotten from the incumbent. In order to avoid information being gathered from some selected people forming a particular class in the society (chief, titled people and friends), the rest of the questionnaires were administered randomly. Houses selected were not too close and the length and breadth of the village was covered proportionately. Alongside the administration of questionnaires and guided interviews, observations were employed to complement the data collection process.

3. Results

3.1. Change in the Lebialem-Mone Forest Landscape

Satellite imagery interpretation illustrated that over the period of 25 years (1986-2011), the LMFL has actually witnessed some modifications in its configuration (Table 3).
Table 2: Villages where questionnaires were administered

<table>
<thead>
<tr>
<th>Village</th>
<th>Number of questionnaires</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lebialem Division</strong></td>
<td></td>
</tr>
<tr>
<td>Banti</td>
<td>8</td>
</tr>
<tr>
<td>Bechati</td>
<td>8</td>
</tr>
<tr>
<td>Besali</td>
<td>8</td>
</tr>
<tr>
<td>Folepi</td>
<td>8</td>
</tr>
<tr>
<td>Fossimondi</td>
<td>8</td>
</tr>
<tr>
<td>Nkong</td>
<td>8</td>
</tr>
<tr>
<td><strong>Manyu Division</strong></td>
<td></td>
</tr>
<tr>
<td>Bokwa</td>
<td>8</td>
</tr>
<tr>
<td>Ebeagwa</td>
<td>8</td>
</tr>
<tr>
<td>Etoko</td>
<td>8</td>
</tr>
<tr>
<td>Kendem</td>
<td>8</td>
</tr>
<tr>
<td>Taiyor</td>
<td>8</td>
</tr>
<tr>
<td>Takwai</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>96</td>
</tr>
</tbody>
</table>

*Source: Fieldwork, 2012*

Table 3: LMFL configuration (1986-2011)

<table>
<thead>
<tr>
<th>Land-cover classes</th>
<th>1986</th>
<th></th>
<th>2011</th>
<th></th>
<th>% change in land-cover classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area(ha)</td>
<td>% of total area</td>
<td>Area(ha)</td>
<td>% of total area</td>
<td></td>
</tr>
<tr>
<td>Water-body</td>
<td>7429</td>
<td>5</td>
<td>6338</td>
<td>4</td>
<td>-1</td>
</tr>
<tr>
<td>Road/Settlement</td>
<td>2824</td>
<td>2</td>
<td>5893</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Farmland</td>
<td>3472</td>
<td>2</td>
<td>6535</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Disturbed Forest</td>
<td>17993</td>
<td>11</td>
<td>35460</td>
<td>22</td>
<td>11</td>
</tr>
<tr>
<td>Undisturbed Forest</td>
<td>128427</td>
<td>80</td>
<td>105919</td>
<td>66</td>
<td>-14</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>160145</td>
<td>100</td>
<td>160145</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Landsat TM, 1986 and SPOT, 2011*

In 1986, the LMFL had 80% of its surface area covered with undisturbed forest but within 25 years, this had reduced to 66%. The results further revealed that between 1986 and 2011, undisturbed forest and water-body
witnessed a change of -14% and -1% respectively while farmland and road/settlement each increased by 2%. The greatest increased (11%) was registered by disturbed forest (Figure 5 and 6).

![Figure 5: Changes in land-cover of the Lebialem-Mone Forest Landscape](image)

This situation is presented for a better visualization on figure 6. The results have illustrated that there has been a change in the land-cover of the Lebialem-Mone Forest Landscape. With an accuracy assessment result of 96% that was obtained from the 2011 image, it is possible to say that this is an indication of the present field condition. The palpable trend has been the reduction in undisturbed forest which will likely have consequences on the biodiversity that depend on it. It was found necessary to identify the drivers of this alteration in the land-cover of the Lebialem-Mone Forest Landscape.

3.2. Drivers of change in the Lebialem-Mone Forest Landscape

Before delving into the drivers of change in the Lebialem-Mone Forest Landscape, it was important to know if the local populations were actually aware of any changes in their landscape or not. Result from those interviewed
(Figure 7) illustrated that 81(84%) are aware of changes occurring in the LMFL. While 10(11%) are not aware of any changes, 5(5%) had no idea.

Those who said they have noticed a change in the LMFL were unanimous on the fact that forest has reduced over the years. The main drivers of this change as identified by the local population are presented on Table 4.

3.2.1. Farming

This is subsistence farming which involves the clearing of portions of the forest to cultivate food crop both for consumption and sale to purchase some other household needs. This is evident as in this rural landscape, no industrial activity is ongoing and so agriculture is almost the only source of income for the inhabitants of this area. The fact that 81(84%) of those interviewed are farmers corroborates this point. Furthermore, 56(69%) (Table 4), of those who were opined that they have witnessed a change in forest cover of the landscape perceived farming as a major driver. Apart from subsistence farming, the setting up of banana, oil palm and cocoa plantations by individuals has equally engendered the reduction in the forest cover of the LMFL. An increased in the price of cocoa from 400FCFA/kg in the 1990s to between 1,100 and 1,225 FCFA in 2007 (Elong, 2011) has forced many people in Cameroon and in the LMFL which has favourable conditions for such an activity to invest in this sector. This has been seen in this area as a means of diversifying income sources since for palm nuts, one can easily sell the nuts or locally transformed them to palm oil for eventual sale at the local market (photo 1). The locals are not only clearing down their old palm trees to plant new and high yielding species but are equally extending their farm holdings to the detriment of the forest.
Table 4: Drivers of change as identified by those who have witnessed a change in the forest cover of the Lebialem-Mone Forest Landscape

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Number of respondents</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farming</td>
<td>56</td>
<td>69</td>
</tr>
<tr>
<td>House construction</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Timber exploitation</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Population increase</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Fuelwood</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>81</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Fieldwork, 2012

3.2.2 House construction

This was viewed by 10(12%) of those who have perceived a change in the LMFL as another cause. House construction has a double effect on the forest of the landscape. The first effect occurs when the population does actually clear the forest to make space for the structure and secondly the wood use for roofing is still gotten from this forest. From first view this might seem insignificant but if one takes the cumulative effect over the years, one sees that this certainly has considerable effect on the forest with new houses being constructed in the villages (Photo 2). Note the difference in the colour of the zinc on the first photograph (the brown colour is evidence of the old nature of the buildings (built in 1985) while the radiating colour of the other zinc shows that there are relatively new structures (2005). Equally note the forest at the background on the two photographs.

3.2.3. Timber exploitation

The forest of the LMFL is found in a communal land implying that it can be used for other purposes other than forestry. It is thus within this backdrop that a timber exploitation licence was issued to Wijma a Dutch company (Collomb and Bikié, 2000) to undertake logging activities in the area (Figure 8). This activity which went on between
2004 and 2006 in the area was welcomed by the villagers of Taiyor, Takwai, and Ebeagwa for those that were actually sampled and certainly in Ekpor, Mbanga-Pongo and Sabes (neighbouring villages to the concession) as it served as a source of employment to the local population.

Figure 6: Land-cover of the Lebialem-Mone Forest Landscape, 1986 and 2011
After boiling the palm nut, it is crushed on the stony flat surface (1) usually with the legs. Water (from the stream) is used to wash the oil out of the chaffs (2) and nuts (3) which then sips to the trough (4). Since oil does not mixed with water, it is then collected from the trough and cooked in the fuel container (5) for at least one hour thirty minutes (depending too on the intensity of the flames).
Equally royalties paid by the forest company that is, 10% of the total amount (since 50% and 40% is channelled to the central and council treasuries respectively) was used for constructing class rooms and repair water supply in Taiyor while a village hall was built in Takwai. Though this activity is appreciated by the villagers for the reasons mentioned above, 8(10%) of those who had witnessed a change on the landscape attributed it to timber exploitation.

3.2.4. Population increase

Population increase and its cumulative effects of the need for more land for farming to feed the increased number of people in households, needs to cultivate large portions of land for increased yields (all things being equal) so as to sell some of the cultivated crops for money income to take care of other family requirements as well as land for construction and increase demand for building material (wood) was seen by 4(5%) of those people who have perceived a change in the Lebialem-Mone Forest Landscape as one of the main drivers. Statistics from the Bureau Central des Recensements et des Etudes de Population (BUCREP), (2010a) showed that the population of the South West Region (which the LMFL is part) has increased over time and is projected to be in a constant rise (Figure 9).

In the population of the South West Region for 2010, 52% lived in the rural areas (BUCREP, 2010b). Despite the fact that one could not disintegrate the statistics that are specific to the villages of the study area, it is highly probable that the relatively high numbers of rural dwellers have as immediate consequence the cutting down of forest for the activities mentioned above.
3.2.5. Fuelwood

According to 3(4%) of those who have perceived a change in the LMFL, fuelwood consumption is equally a major driver. All the villagers in the study area that were interviewed use solid fuel which is gotten from the surrounding forests. This is confirmed by statistics at the national level which demonstrate that 82% (Ministry of Economy, Planning and Regional Development, 2010) of people in Cameroon still utilize solid fuels. At individual household level, this appears to be less consequential but if all the wood is summed-up, one will see that fuelwood consumption has far-reaching effects on the forest of the LMFL.

Figure 8: Timber exploitation in the Lebialem-Mone Forest Landscape
4. Discussions and conclusion

This study was aimed at assessing the land-cover change that have occurred in the LMFL, and identifying the current challenges to protecting the Cross river gorilla so as to develop strategic recommendations based on field realities to Fauna and Flora International and its local partner the Environment and Rural Development Foundation who are striving to designate a sanctuary for the Cross river gorilla in the landscape. For this purpose, it employed satellite images for 1986 and 2011 to demonstrate the land-cover changes that have occurred in the Lebialem-Mone Forest Landscape. The major outcome was that undisturbed forest reduced by -14% while farmland and disturbed forest increased by 2% and 11 % correspondingly over the 25 years period considered for this study. Results showed that 84% of the sampled population were actually aware of these changes. It therefore proved that with the use of satellite images in concert with appropriate fieldwork, the change in
land-cover and related land use could be established. A number of studies have equally employed satellite images to illustrate changes in land cover classes, for example those carried out by Twumasi and Merem (2007) in the River Niger Basin and Yuan et al., (2005) in Minnesota. Studies by Kah (2006) and Neba (2003); both showed a decrease in the forest cover of their areas under study.

The main current drivers of change in the LMFL were identified by the sampled population and field observation to be subsistence agriculture (84% of the sampled population are farmers) leading to increase deforestation and fragmentation of the LMFL. This is because the local population are struggling to cultivate food crops both for consumption and for sale so as to have money to meet up with other demands especially with the onset of the economic crisis that affected Cameroon in the late 80s and is still going on. According to Varughese, (2000, p.193): “in a country where over 80% of the population depends entirely on agriculture and forest products for food and fuel, forested lands always face the risk of being used at an unsustainable rate” which is the case of the LMFL.

The result of studies by Sunderlin et al., (2000a) and Mertens et al. (2000), which pointed out that the rate of deforestation increased significantly in the decade after the 1986 onset of the crisis, as compared to the decade prior to the crisis corroborates this assertion. Equally, macroeconomic instability can lead to unforeseen and grave consequences not only for the well-being of farmers but also for efforts to protect remaining tropical forest (Sunderlin et al., (2000b) which is the same scenario occurring in the LMFL. The consequences of these adjustments on forest lands were not only felt in Cameroon Kaimowitz et al., (1998) and the fact that Cameroon attained the completion point of the Heavily Indebted Poor Country (HIPC)
Initiative in the year 2006\textsuperscript{7} and is struggling to be an emerging country in 2035 is testimony to the hardship faced by certain segment of the population especially those in the rural areas including the LMFL.

Other drivers of change in the area were house construction, timber exploitation, population increase and the harvesting of fuel-wood as 96\% of the rural population of Cameroon depend on it and charcoal as principle cooking fuel (Essama and Gockowski, 2000). In addition to the current threats large scale palm oil production, logging and landslides were identified as the emerging challenges. The study suggests that for the gorilla habitat to be conserved, alternative means of income to take the local population off the forest have to be sought. This could be beekeeping, snail and cane rat farming, intensive agriculture with the use of fertilizers and high yielding species so that cultivated portions can produce much quantities and part of the land left for wildlife (land sparing).

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